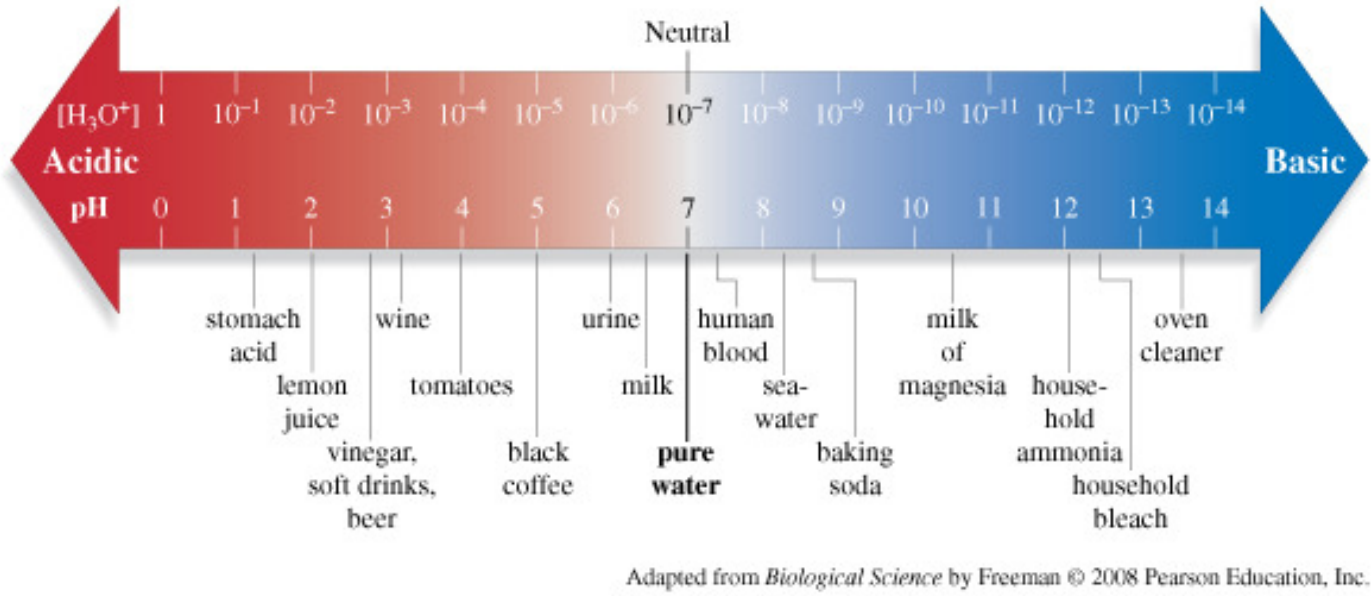
Name _____

# pH Practice

pH expresses the molar concentration of hydronium ions in an aqueous solution on a logarithmic scale.
Each pH unit represents a TENFOLD difference in $H^+$ and $OH^-$ concentrations!

$$pH = -\log[H_3O^+]$$
$$[H_3O^+] = 10^{-pH}$$




Adapted from *Biological Science* by Freeman © 2008 Pearson Education, Inc.

(Note that it is common to use the hydrogen ion, $H^+$, to represent the hydronium ion, $H_3O^+$.)

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [H+] | 1 | $10^{-1}$ | $10^{-2}$ | $10^{-3}$ | $10^{-4}$ | $10^{-5}$ | $10^{-6}$ | **$10^{-7}$** | $10^{-8}$ | $10^{-9}$ | $10^{-10}$ | $10^{-11}$ | $10^{-12}$ | $10^{-13}$ | $10^{-14}$ |
| pH | 0 | 1 | 2 | 3 | 4 | 5 | 6 | **7** | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| [OH-] | $10^{-14}$ | $10^{-13}$ | $10^{-12}$ | $10^{-11}$ | $10^{-10}$ | $10^{-9}$ | $10^{-8}$ | **$10^{-7}$** | $10^{-6}$ | $10^{-5}$ | $10^{-4}$ | $10^{-3}$ | $10^{-2}$ | $10^{-1}$ | 1 |

- Acidic solution: pH < 7
- Neutral solution: pH = 7
- Basic solution: pH > 7

- As pH decreases, acidity increases.
  - The LOWER the pH, the more ACIDIC a substance is
- As pH increases, acidity decreases.
  - The HIGHER the pH, the more BASIC a substance is

## Working with a logarithmic scale

Problem: What happens to the concentration of hydrogen ions [H+] vs hydroxide ions [OH-] when the pH of a solution is changed from 5 to 8?

**Hint 1.** Determine in which direction the pH went

- If the pH increased:
  - IE: More BASIC
    - [H+] decreased and/or
    - [OH-] increased
- If the pH decreased:
  - IE: More ACIDIC
    - [H+] increased and/or
    - [OH-] decreased

**Hint 2.** Determine how much the pH changed

- Remember, each pH unit represent a TENFOLD difference in $H^+$ and $OH^-$ concentrations
- Subtract the two pHs to determine the number of places to move the decimal
  - Ex: 8-5 = 3
- If the concentration increased:
  - Move the decimal to the right
  - Ex: $1x10^3 = 1{,}000$
- If the concentration decreased:
  - Move the decimal to the left
  - Ex: $1x10^{-3}$ or $1/10^3 = 0.001$

Solution:

## The relationship between pH and acidity

Problem: Rank the following from most acidic to least acidic.

pH= 5 pH = 14 pH = 3 $[H_3O^+] = 10^{-2}$ $[H^+] = 10^{-6}$ $[OH^-] = 10^{-4}$

**Hint 1.** How to approach the problem

- Notice that three of the choices give the pH value, whereas three of the choices give concentrations. So the first step is to convert all items to a pH value before trying to rank them
- Remember that $[H_3O^+]$ and $[H^+]$ are often used interchangeably.
- $[OH^-]$ needs to be converted to $[H^+]$

**Hint 2.** Determine the pH of a solution with $[H_3O^+] = 10^{-2}$ (or $1.0 \times 10^{-2} M$)

- Recall the relationship between pH and hydronium ion concentration:
  - $pH = -\log[H_3O^+]$
- $pH = -\log[H_3O^+] = -\log 10^{-2} = -(-2) = 2$

**Hint 3.** Determine the pH of a solution with $[H^+] = 10^{-6}$ (or $1.0 \times 10^{-6} M$)

- Recall the relationship between pH and hydrogen ion concentration:
  - $pH = -\log[H^+]$
- $pH = -\log[H^+] = -\log 10^{-6} = -(-6) = 6$

**Hint 4.** Determine the pH of a solution with $[OH^-] = 10^{-4}$

- Remember pH is defined by the negative logarithm of $H^+$ concentration
  - **NOT** $OH^-$ concentration!
- pH + pOH = 14
  - $pOH = -\log[OH^-] = -\log 10^{-4} = -(-4) = 4$
  - $14 - 4 = 10$

- Or, picture the number line from the first page
  - $[OH^-] = 10^{-4} \rightarrow [H^+] = 10^{-10}$
  - $-\log[H^+] = -\log 10^{-10} = -(-10) = 10$

**Hint 5.** Determine the relationship between pH and acidity.

- Remember, in comparing solutions, the solution with the highest pH is the **LEAST** acidic!
- Acidic solution: $pH < 7$
- Neutral solution: $pH = 7$
- Basic solution: $pH > 7$

Solution:

Most Acidic Least Acidic

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